

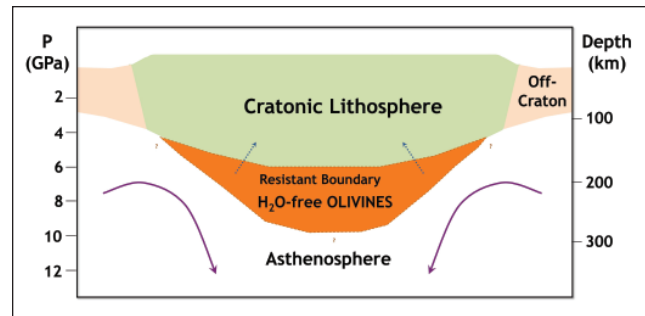
# How Tiny Amounts of Water in the Deep Earth Saved Continents

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The Earth is unique in our solar system not only because of its water-filled oceans and oxygen-rich atmosphere, but also because of its plate tectonic engine. The layer on which the tectonic plates float is called the asthenosphere and is made of slowly deformable rock. Huge chunks of the crust and mantle sink constantly into the asthenosphere when they become old and dense at subduction zones, while new crust is being made at mid-ocean ridges. Finally, continents break up and collide over hundreds of million-year cycles, thereby churning up even more crust at their edges. And yet, over its 4.5-billion-year history, the Earth has managed to preserve some very old rocks—some more than 3 billion years old. What prevented these rocks from being recycled into the asthenosphere?

Recent work published in the September 2, 2010, issue of *Nature* by Johnson Space Center (JSC) and colleagues at the University of Frankfurt, and Arizona State University bring answers to this puzzle. For this study, the team turned its attention to the ancient cores of continents, called cratons, where the oldest rocks can be found. Cratons are also part of tectonic plates and therefore float on the asthenosphere. The cratons resemble icebergs in an ocean with deep keels, down to 200 kilometers, protruding into the asthenosphere. Samples from these keels, brought up by magmas—called kimberlites—that traverse them, are available. The latter are incidentally famous for also bringing up diamonds. It is known that these roots are as old as the rocks found at the surface—around 3 billion years old. Scientists have long tried to explain why these keels exist, as it would be expected that they would be eroded away by the surrounding hot and dynamic asthenosphere. It has been proposed that the keels help the cratons float because they are less dense than the asthenosphere. Over their billion-years history, magmas have removed dense elements (iron, aluminum, calcium) from the keels. Geologists also think that the cold temperature, compared to that of the asthenosphere, make the keels stiff and resistant. Finally, scientists have long proposed that water—or, more exactly, the absence of it in the keel—could make the keel strong and resistant. This last hypothesis has never been proven until this study.



**Fig. 1.** A sketch of a cross-section of a craton. A layer of resistant dry rock (orange) and the bottom of the cratonic keel prevents it from being eroded away over billions of years by the convection in the asthenosphere (purple arrows).

JSC has the capability of measuring tiny amounts of water locked up in minerals. The main mineral of the rocks from the keel of the Kaapvaal craton located in South Africa was analyzed. The more this mineral—called olivine—contains water, the softer it becomes. On the contrary, olivines from the bottom of the craton are dry, making them hard to deform and break (figure 1). So here is a mechanism for rendering the keels of cratons resistant: they have a shell of very hard, dry olivines. This work has crucial implications on our understanding of Earth plate tectonics, why continents exist, and the evolution of planetary interiors since the formation of the solar system.